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DIAGRAM OF THE ENTROPY-TEMPERATURE OF THE EQUILIBRIUM PHASES OF A LITHIUM BROMIDE SOLUTION IN WATER

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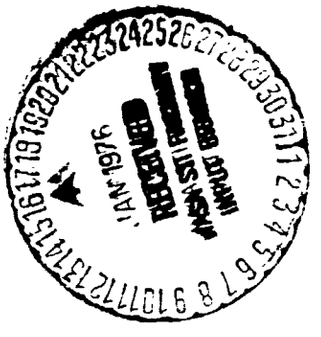

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16. Abstract

The thermodynamic properties of an aqueous lithium bromide solution were studied by a series of researchers, who obtained valuable experimental data. The enthalpy diagram ξ - i of a solution of lithium bromide in water and several tables were prepared on the basis of these data. The enthalph diagram was defined more accurately. The available data also made it possible to prepare the entropy diagram s - t of the aqueous lithium bromide solution, which is important for the thermodynamic analysis of combined cycles of an absorptive lithium bromide refrigerator and heat transformers.

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DIAGRAM OF THE ENTROPY-TEMPERATURE OF THE EQUILIBRIUM PHASES OF A LITHIUM BROMIDE SOLUTION IN WATER

Introduction

The thermodynamic properties of an aqueous lithium bromide solution were studied by a series of researchers, who obtained valuable experimental data [1-4]. The enthalpy diagram ξ - i of a solution of lithium bromide in water and several tables were prepared on the basis of these data [4, 5]. The enthalpy diagram was defined more accurately [6,7]. The available data also made it possible to prepare the entropy diagram s - t of the aqueous lithium bromide solution, which is important for the thermodynamic analysis of combined cycles of an absorptive lithium bromide refrigerator and heat transformers. /70

Entropy Diagram of an Aqueous Lithium Bromide Solution

a) Liquid phase. The plotting of the liquid phase of the diagram was done in sequence: plotted at the coordinates s - t were the curves of constant concentrations in the zone of complete solubility of the lithium bromide in water -- from 0 to 70% lithium bromide; the curves of constant pressures p and constant enthalpies i were then plotted. In addition, a network of curves of the constant concentrations ξ was plotted

on the basis of the tabular data [5]. These data do not permit the direct plotting of the isobars p and the isoenthalpy curves i. For this reason, we plotted auxiliary graphs of the constant temperature t-const at the coordinates lgp - ξ and i - ξ (fig. 1,2). Plotted on these graphs were the curves of the constant pressures p and constant enthalpies i, and the relations $p = f(t, \xi)$ and $i = f(t, \xi)$ were obtained. The latter made it possible to plot the network of isobars and isoenthalpy curves on the s - t diagram (fig.3), on which the curve of crystallization of the solution was also plotted [5].

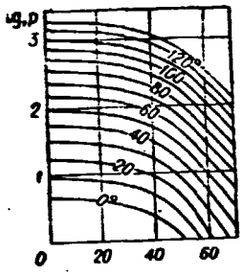

Figure 1.- Pressure as a function of the concentration of the aqueous lithium bromide solution.

Concentration %

b) Vapor phase. In order to plot the curve of constant concentrations and isobars p, we used the tabular functions $s = f(p, \xi)$ for the vapor phase [5] and the previously plotted liquid portion of the s - t diagram. The points with the parameters p_i and ξ_i in the vapor portion of the diagram are located at the intersections of the adiabatic curves s_i and the isothermal curves t_i. The values of $s_i = f(p_i, \xi_i)$ were taken from the tables [5], and the isothermal curves were drawn through the points of intersection of the p_i-const and ξ_i-const curves of the vapor portion of the diagram under the condition of equilibrium of the phases. The points are futher connected with identical values of p_i and ξ_i, forming a network of isobars p and curves of constant concentrations ξ in the vapor phase of the s - t diagram. /71

Taking into consideration the fact that the vapor phase is represented by a pure component -- water vapor --, the network of curves of the constant concentrations ξ in the vapor portion should be viewed as conditional. Here, the curve of the constant concentration $\xi = 0$ represents the righthand boundary curve of the dry saturated water vapor. The curves of the constant concentrations $\xi > 0$ are characterized by the phase of overheated water vapor, equiponderant to the phase of the solution of given concentration.

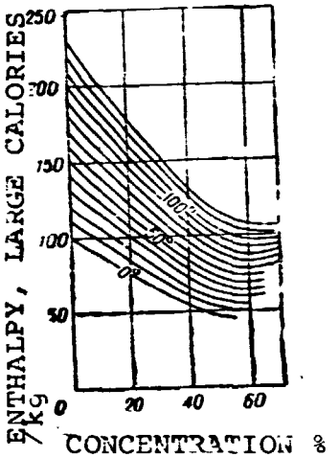

Figure 2.- Enthalpy as a function of the concentration of aqueous lithium bromide solution.

The curves of constant enthalpies i were plotted according to the tables of overheated water vapor [8]. Here, the difference in the source of the reading in determining the entropy in the tables of M. P. Vukalovich [8] and H. Löwer [5] equal to $\Delta s = 0.82$ large calories/kg°C, was taken into account.

c) Moist vapor zone. The curves of constant concentrations i and pressures p in the moist vapor zone were not plotted in the entropy diagram. These curves are formed in every case in conformity with the conditions of the thermodynamic cycle. This plotting is performed by solving a system of equations /72

$$s = xs' + (1 - x)\, s_0. \qquad (1)$$

$$\xi = x\xi' + (1 - x)\xi_0. \qquad (2)$$

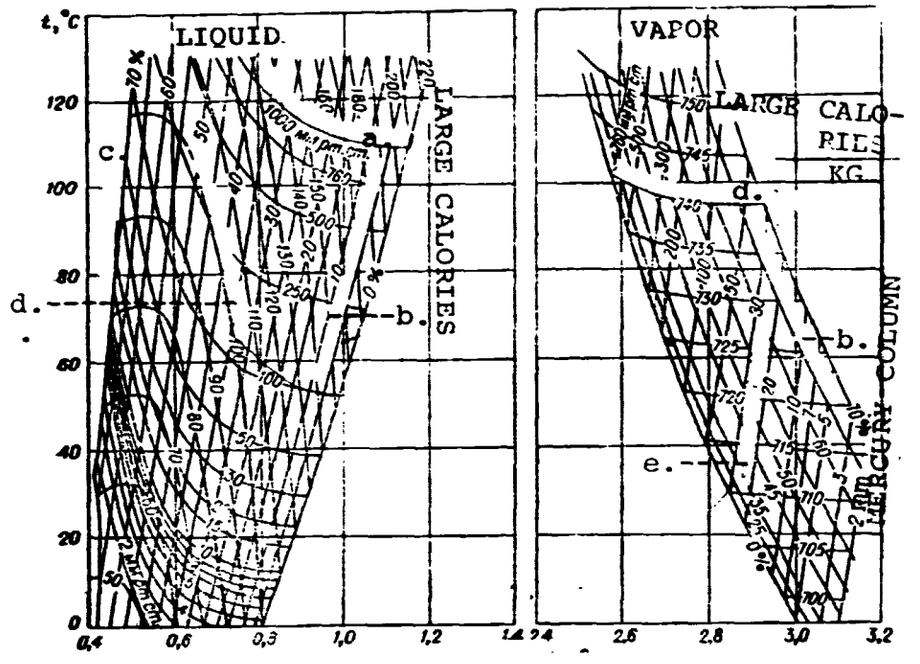

Figure 3.- Temperature-entropy diagram of equilibrium phases of an aqueous lithium bromide solution.

Key : a - constant pressure, 1000 mm mercury column b - constant concentration; c - curve of crystalization; d - constant enthalpy; e - constant pressure; f - s, large calories/kg °C.

where s, s', s_o are the entropies of the liquid vapor mixture, the vapor phase and the liquid phase; x is the degree of dryness of the moist vapor, ξ, ξ, ξ_0 are the general concentration of the liquid vapor mixture, the concentration of the vapor phase and the concentration of the liquid phase.

A series of isothermal curves is plotted in the s - t diagram in the temperature range stretching between the beginning and the end of the process (absorption, desorption). The intersection of the corresponding isothermal curves with the isobars of the process in the vapor and liquid phase yields the values of the entropies of the liquid s_0 and of the vapor s' and the solution concentration ξ_0. In view of the non-volatile

nature of lithium bromide in the temperature range examined, the concentration of the vapor phase in the lithium bromide is $\xi' = 0$. Then, equation (2) is solved with regard to x:$x = 1 - \frac{\xi}{\xi_0}$. Thus, having the values of s_0 ans s' from the s - t diagram and of x from equation (2), we obtain the values of the entropies of the liquid vapor mixture s from equation (1). In conformity with the values of the entropy s for the given temperatures t in the s - t diagram, we plot the points that determine the position of the ξ - const and p-const curves in the moist vapor zone (figure 4, curves: c - a - absorption; a - c - desorption). The enthalpy values of the points lying on the ξ- const and p- const process curve are obtained from the following statement:

$$i = xi' + (1 - x)\, i_0. \qquad (3)$$

where i is the enthalpy of the point in the moist vapor zone, : i' and i_0 are the enthalpy of the points lying on the isobar of the process in the vapor and liquid phases, equiponderant with the initial point in the moist vapor zone, and x is the degree of dryness of the moist vapor.

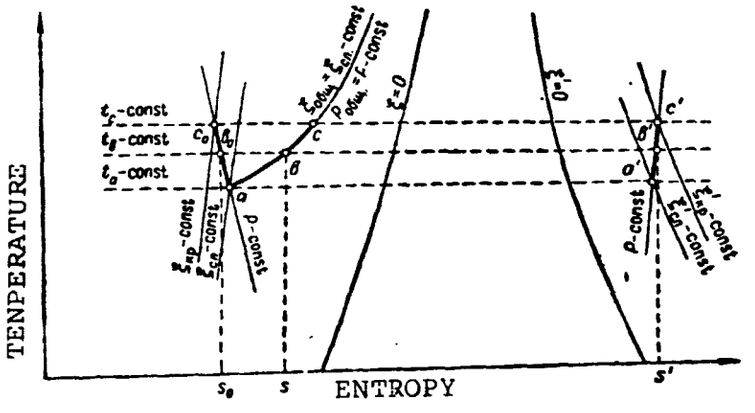

Figure 4.-
Plotting of curve of constant general concentration and constant pressure in the moist vapor zone in the temperature entropy diagram.

The published data on the thermodynamic properties of an aqueous lithium bromide solution [1-4] make it possible to plot the entropy diagram, with the help of which it is possible to analyse the combined thermodynamic cycles in the most graphic and effective manner. /73

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Literature

1. International Critical Tables, Vol. V, p.133.
2. International Critical Tables, Vol. III, p. 363
3. W. Penington, Refrigeration Engineering, 1955, May.
4. L. M. Rosenfeld, M. S. Karnaukh. Zhurnal Tekhnicheskoy Fiziki, 1958, vol. XXVIII, No. 3.
5. H. Löwer. Dissertation, 1961.
6. S. Hasaba, T. Uemura. Refrigeration (Japan), 1961, vol. 36.
7. I. P. Usiyukin. Kholodil'naya Tekhnika, 1969, No. I.
8. M. P. Vukalovich. Teplofizicheskiye svoistva vody i vodyanovo para "Mashinostroyeniye", 1967.